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METHOD AND APPARATUS FOR BROWNING AND COOKING FOOD PRODUCTS WITH STEAM

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SPECIFICATION

TITLE

METHOD AND APPARATUS FOR BROWNING AND COOKING FOOD PRODUCTS WITH STEAM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. Section 119(e) of U.S. Provisional Patent Application Serial No. 60/401,097, entitled "Process for the Browning and Fully Cooking of Meat, Poultry, Seafood, and Vegetable Products Using Superheated Steam", filed August 5, 2002 and, under 35 U.S.C. Section 120, of U.S. Utility Patent Application Serial No. 10/349,324, entitled "Method and Apparatus for Browning and Cooking Food Products With Superheated Steam", filed January 23, 2003, which are hereby incorporated by reference in their entireties into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to cooking food products, such as meats and vegetables, in a faster, more efficient manner.

2. Description of the Related Art

[0003] It is known in the art to use superheated and/or conventional steam to cook food products. See, e.g., U.S. Patent No. 5,075,121, issued to Desage et al. or U.S. Patent No. 6,310,325, issued to Colburn.

[0004] It is believed, however, that the prior art fails to provide a method or an apparatus for faster cooking of a food product, using a combination of superheated and conventional, saturated steam, while maintaining desirable product yields.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is a purpose of the present invention to provide a faster method of cooking food products, while maintaining high product yield.

[0006] It is another purpose of the present invention to provide a faster method for browning and cooking food products, in either order.

[0007] It is still another purpose of the present invention to use superheated steam in a high temperature environment, to brown food products, in association with combined superheated/conventional steam cooking.

[0008] It is another purpose of the present invention to more evenly brown and cook a food product in a single cycle, on a single conveyor path.

[0009] It is a further purpose to provide an improved superheated browning apparatus and method which can be used either prior to or after cooking of the food product using a combination of superheated and conventional steam.

[0010] To achieve the forgoing and other purposes of the present invention, the invention generally includes the use of "superheated" steam to cook food products, which cooking can occur with or without separate heat. By superheated steam it is meant steam heated to a temperature higher than the boiling point corresponding to its pressure: said steam is relatively dry.

[0011] More particularly, the present invention uses superheated steam (above 212° F and preferably 230° to 750° F) to cook a food product more quickly. The release of the superheated steam preferably occurs about 4" from the food product.

[0012] Processing time can be further decreased when the food product is placed in a superheated steam environment in combination with lower temperature, i.e., conventional, saturated steam (160°F to 212°F). This mixing of superheated and non-superheated steam can be utilized to create the desired atmosphere in the processing equipment to maximize product yield, while decreasing time for thermal processing to a desired internal product temperature.

[0013] Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The patent or application file contains "drawings" in color. Copies of this patent or patent application publication with color drawings will be provided by the Office upon request and payment of the necessary fee.

[0015] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0016] FIG. 1 is a schematic side view of a superheated steam food product processor according to a first embodiment of the present invention.

[0017] FIG. 2 is a schematic front view of the processor shown in Fig. 1.

[0018] FIG. 3 is a side view of a processor used in accordance with a second embodiment of the present invention, including a radiant wall oven.

[0019] FIG. 4 is a front view of the processor shown in Fig. 3.

[0020] FIG. 5 is a partial side cross sectional view of the processor shown in Fig. 3.

[0021] FIG. 6 is a side cross sectional view of a processor with separate browning and cooking chambers.

[0022] FIG. 7 depicts a browned chicken breast according to the present invention.

[0023] FIG. 8 depicts browned sausages according to the present invention.

[0024] FIG. 9A depicts uncooked pork chops used in the Examples.

[0025] FIG. 9B depicts pork chops browned using a conventional method.

[0026] FIG. 9C depicts pork chops browned using a method according to the present invention.

[0027] FIG 10A depicts hot peppers used in the Examples.

[0028] FIG. 10B depicts hot peppers browned using a conventional method.

[0029] FIG. 10C depicts hot peppers browned using a method according to the present invention.

[0030] FIG 11A depicts uncooked salmon filets used in the Examples.

[0031] FIG. 11B depicts salmon browned using a conventional method.

[0032] FIG. 11C depicts salmon browned using a method according to the present invention.

[0033] FIG. 12A depicts an uncooked turkey breast used in the Examples.

[0034] FIG. 12B depicts turkey breast browned using a conventional method.

[0035] FIG. 12C depicts turkey breast browned using a method according to the present invention.

[0036] FIG. 13 is a side view of a cooking device according to the present invention.

[0037] FIG. 14 is a front view of the cooking device shown in FIG. 13.

DESCRIPTION OF THE EMBODIMENTS

[0038] The present inventors have discovered that superheated steam, when applied to food products, cooked or uncooked, can lead to improved surface browning of the food product. In this regard, the superheated steam can even be applied to the food product at ambient temperature, i.e., without any other heat source influence. Alternatively, the superheated steam can be applied in the presence of heat, including infrared, up to at least 1500°F. In addition, for faster cooking, while maintaining yields, the food product can be cooked, either prior to or after browning, via superheated steam or a combination of superheated steam and conventional steam, as discussed below.

[0039] By food products, it is meant foods such as meat (e.g., bacon, pork chops, sausage, hamburger patties), poultry (e.g., whole turkey, chicken breasts or wings), seafood, vegetables (e.g., French fries, peppers), convenience or snack foods (e.g., burritos), pizza, breads, cookies, and pastries. Other such food products are contemplated by the present invention, and would be known to one of ordinary skill in the art.

[0040] In a first embodiment, shown in Figs. 1-2, superheated steam is applied to food products in a processor 10. The processor 10 has walls 12 that are preferably made of stainless steel, and define an internal chamber 14 for browning food products 16.

[0041] A product belt or conveyor 18 is shown for continuously moving the food products 16 through the processor 10. In this regard, the processor 10 includes an inlet 17 through which the conveyer 18 enters, and an outlet 19 at the other end of the processor 10, through which the conveyor 18 exits.

[0042] It is not necessary to close off the inlet 17 and/or outlet 19 when using the superheated steam according to the present invention. That is, even though the superheated steam is under pressure in the piping described below, there is no need to provide a pressure-tight environment for its use.

[0043] As an alternative to the conveyor 18, the processing could be static, wherein one or more food products 16 is browned in a batch procedure, i.e., loaded into the processor 10 and removed after the browning cycle. A batch type procedure would be more appropriate for browning smaller quantities of food products, such as in a home or a small institutional kitchen (either of which would require a superheated steam source).

[0044] Figs. 1 and 2 also show superheated steam 20 being injected into the processor 10 from a superheated steam source 22. The source 22 can be a boiler, such as a Chromalox Super Heater ZMP059. The superheated steam 20 is preferably introduced into the chamber 14 of the processor 10 via stainless steel tubes 26, 28, which are part of a line 25 extending from the source 22 to the inside of the processor 10.

[0045] The tubes 26, 28 preferably include a plurality of tubes 26a, 26b, 28a, 28b, etc., along the chamber 14, so that the superheated steam 20 delivery is continuous along the length of the chamber 14. Each tube is preferably a ¾" OD stainless steel tube with six to eight (8) .035" X .785" slots 29 for even steam delivery throughout the length of the chamber 14 of the processor 10. The tubes 26, 28 can be positioned above, below and even on the sides of the food products 16 being conveyed through the browning chamber 14 so as to assist in browning the entire surface of each food product.

[0046] Of course, when the food product 16 is exposed to the superheated steam, the product begins to cook to some extent. However, the browning according to the present invention is completed prior to the food product 16 being fully cooked. Of course, in embodiments described below, browning and cooking can be performed relatively simultaneously, wherein the dwell time of the food product in the presence of a heat source, such as steam (superheated and/or conventional), is increased so that the food product is fully cooked, either prior to or after browning.

[0047] The superheated steam 20 is introduced via the steam line 25 into the processor 10 above 212°F and up to about 750°F, and preferably about 300 - 500°F, and more preferably about 400°F. The temperature is dependent upon the type of food product. For example, in order to brown bacon, a temperature of about 500°F would be appropriate. Preferably the line runs at a constant pressure of 15 psi.

[0048] The superheated steam 20 temperature/pressure/flow can be measured by sensors 27, including e.g., a thermocouple, positioned in the stainless steel tubes 26, 28 just prior to a point where the steam 20 exits at slots 29 into the atmosphere of chamber 14. The variables in the line 25 are basically steam flow and temperature, which are controlled electronically. The sensors 27 are connected to a controller 32, such as the Honeywell UDC 3300 Digital Controller, which controls the steam source 22. An appropriate temperature sensor can be a Spirax Sarco temperature probe connected to a temperature indicator, controller or flow computer. Spirax Sarco is located in Blythewood, South Carolina. A suitable pressure sensor

can be a Spirax Sarco pressure sensor. Generally, the pipes 26, 28, sensors 27, etc., of the steam line 25 are stainless steel. Also, all piping is to be insulated.

[0049] The temperature in the chamber 14 is measured by a thermocouple 34, also connected to the controller 32.

[0050] It has been found that, when the superheated steam 20 is intentionally directed towards the surface of the food product 16, more rapid browning of the surface occurs. In this regard, it has been found that placing the slots 29 a distance "l" about 1" to 18" from the food product 16 surface provides preferred results.

[0051] Putting the slot 29 closer to the food product 16 surface than about 1" may cause a brown stripe to be formed on the food product surface, or light food products might be blown around on the conveyor 18 by the emitted steam. Neither of these results is preferred. Putting the superheated steam slot 29 farther away than about 18" may not lead to optimum browning of the food product surface, since the superheated steam may loose its desired temperature from the slot 29 to the food product, or may not impinge directly on the food product surface.

[0052] For the effectiveness of the superheated steam, it also appears necessary for the steam to actually contact the surface of the food product. Accordingly, food products in packaging would not be browned like an unpackaged food product using the present invention.

[0053] Tests were performed to determine the effectiveness of superheated steam in browning food products in an ambient atmosphere. In these tests, superheated steam was generated by running a coil of conventional steam through a radiant wall oven, as discussed below. These tests show that even at ambient temperatures, when the superheated steam is impinged upon the product surface, browning can occur.

TABLE 1

Radiant Wall Oven Temp. °F	Shop Temp. °F	Steam Temp. °F	Comments
1000°F	76°	322°F	Started to brown
1050°F	77°	335°F	Little more browning
1100°F	77°	370°F	Good browning
1150°F	78°	372°F	Excellent browning 1.5 min.

[0054] It should be understood that although the order of cooking/browning will ordinarily be browning first in the processor 10, then full cooking, these steps can be accomplished in the reverse order. That is, for on-site cooking (such as in franchise food outlets), where yield is not so important, it may sometimes be desirable to perform the cooking step first. In many cases where the food product has been frozen, it is important to do the browning step first in order to assure that the browning effect is limited to the outside of the product, with little penetration.

[0055] If the browned food product 16 was not previously cooked, it can be removed from the conveyer 18 and stored until it is ready for cooking. For example, the browned food product 16 can be frozen, shipped, and cooked in a commercial or home oven. Alternatively, as described below, the browned food product 16 can be immediately cooked in a processor 10, including an integral heat source or in a separate heat or steam source, as discussed below. If the food product was cooked prior to browning, the browned food product 16 can then be frozen and shipped and, at the destination, thawed and heated in a commercial or home oven.

[0056] The present invention also allows the surface of a frozen food product to be browned by the use of superheated steam, without having to thaw the food product. In this way, the food product stays frozen through browning, packaging, shipping and storage, until it is ready for cooking.

[0057] In the above-described first embodiment, the browning can take place at ambient temperature in the processor 10. In the following second embodiment, the processor 10 includes a single chamber in which browning occurs in the presence of both superheated steam and added heat. The temperature of the added heat can be from just above ambient to in excess of 1500°F, preferably towards the upper end of this range.

[0058] As shown in Figs. 3-4, the walls 12 of the processor 10 again define the internal chamber 14 for browning food products 16. The conveyor 18 continuously moves the food products 16 through the chamber 14. As an example of actual operating conditions, the conveyor 18 may be about 40" wide, and about 40' long. One square foot of belt 18 should be able to hold, e.g., nine strips of bacon.

[0059] In addition, the processor 10 includes a heat system 40 which, may be in the form of, e.g., a steam cabinet, a conventional, non-infrared oven, or an infrared, e.g., radiant wall oven. The temperature in a steam cabinet would generally be about 170° to 212°F, but usually about 212°F. In a conventional, non-infrared oven the operating temperature would usually be about 540°F. In an infrared oven, the temperature would be about 800° to 1540° F.

[0060] If a relatively lower temperature heat source is used, an external superheated steam source, like 22 described above, would be used to provide the superheated steam for browning. With the relatively high temperature heat source described above, either an external superheated steam source 22 would be used, which may already be available at a processing plant, or it is possible to use the heat source per se to produce the superheated steam, as discussed below.

[0061] The present inventors have found that any food product subjected to infrared heat in combination with superheated steam will exhibit more even and darker surface browning than conventional browning methods at an infrared oven operating temperature above 540°F, and preferably between 540°F and 1540°F. Also the temperature of the superheated steam entering the infrared zone of the infrared oven preferably ranges from about 297°F to 792°F.

[0062] A preferred infrared oven is a radiant wall oven manufactured by Pyramid Food Processing Equipment Manufacturing, Inc. of Tewksbury, Mass., the Assignee, with which the superheated steam source described above is incorporated.

[0063] Radiant wall ovens, used alone and in combination with other cooking devices, such as microwave ovens, are described in U.S. Patent Nos. 5,512,312 and 5,942,142, each issued to Forney et al., the disclosures of which are expressly incorporated herein in their entireties.

[0064] Such a radiant wall oven 40a, as shown particularly in Fig. 5, includes one continuous wall 42 extending peripherally around and defining the boundary of an oven chamber 44, which is a part of the browning chamber 14 in this embodiment. This wall 42 is heated via a heat plenum 46 above and below the wall 42. The walls 12 surrounding the plenum 46 are insulated. A gas burner 47 directs a flame into the plenum 46, preferably at the bottom, so that hot gases from the flame surround the radiant wall 42 within the plenum 46. An exhaust 48, located at the top of the processor 10, is necessary to direct the captured heat, gases, smoke, etc. away from the plenum 46. The heat from the high-temperature exhaust 48 can be used to generate superheated steam, as discussed below.

[0065] With a high temperature infrared oven 40a such as this, a hood 50 at either end of the processor 10 is also necessary to capture the escaping heat. Fig. 5 shows vents 52 and 54 positioned to draw off gases, as well as any smoke present, from the oven chamber 44 on a continuous basis. A fan or suction unit 56 is connected to these vents. In Fig. 4, the hood 50 is not shown for clarity of the remaining components.

[0066] A steam source 60, such as a pipe leading from a Latiner Boiler (e.g., 5HP, 260,000 BTU) (not shown), provides conventional steam 62 past a bypass 63 and along a path of pipes 65 to a coil 64, preferably made of stainless steel. The coil 64 is located in a housing 61 in fluid communication with the high temperature exhaust 48 of the oven 40a. In this regard, current radiant wall ovens can be retrofitted to receive a coil 64 in their exhausts. Alternatively, the coil 64 can be placed in the plenum 46 of the oven, or can be placed in a separate heat source and directed to the processor 10.

[0067] While the conventional steam 62 is moving through the coil 64 it becomes superheated due to the high temperatures (about 1325°F to about 1540°F). It is at this point that the steam is transformed from conventional steam 62 at 212°F to superheated steam 66 at above 212°F, e.g., at about 750°F to 800°F. When released into the chamber 44 via the slots 29, it is preferably about 400-500°F.

[0068] Thus, the present invention takes relatively low pressure steam and subjects it to high heat to significantly raise the temperature of the steam, and therefore produce superheated steam. In this way, the superheated steam used is not dependent upon increased pressure, but is based on exposure to external BTU's.

[0069] Using the coil 64 to generate the superheated steam is preferred, as it is more economical than using other energy sources. That is, a gas fired radiant wall oven will operate more efficiently and at a lower cost than relying upon a resistance or micro-wave type heating source, both of which rely upon electricity.

[0070] The temperatures/pressures of the superheated steam, oven chamber 44 atmosphere temperature and oven wall 42 temperature are again detected by various conventional sensors 27 in the system and fed to the controller 32 (not shown in Figs. 3-5). Also, the flow of the superheated steam in the line can be measured by a flowmeter, such as a Spirax Sarco flowmeter connected to a controller or to a conventional steam flow computer, such as a Spirax Sarco steam flow computer.

[0071] Preferably, the superheated steam 66 is injected into the processor 10 from above and below the food products 16, or even on the sides, via pipes 68, 70 leading to the pair of stainless steel tubes 26, 28 for even steam delivery throughout the length of the chamber 14 of the processor 10 (which includes the oven chamber 44). That is, preferably the food product 16 is surrounded by the superheated steam during the browning phase. The slots 29 are again

positioned above and below the food products, preferably a distance "l" equivalent to 1" to 18" from the food product 16 surface.

[0072] The product may be subjected to this infrared heat and steam combination for 10 seconds to 240 seconds to effect browning. The amount of time depends on the size and thickness of the food product.

[0073] Separately, as shown in Fig. 5, and as described below, when the processor 10 is used to both brown and cook, the cooking step can include the use of superheated steam alone, or in combination with conventional steam. In this latter regard, Fig. 5 illustrates the introduction of conventional steam through the inlet 58. The source of the conventional steam can again be the Latiner boiler.

[0074] In still another embodiment shown in Fig. 6, the processor 10 can include both a browning chamber 14 as described above, and a separate cooking chamber 44, so that the food products 16 can be sequentially browned and cooked. The conveyer 18 continuously moves the food products 16 from the browning chamber 14 and through the cooking chamber 44.

[0075] Cooking of the food product 16 is dependent upon the thickness of the product, the amount of time that the product is exposed to a heat source, and the intensity of the heat source. Above it is noted that browning can occur in less than 240 seconds. For some thin products (e.g., burgers and sausage patties) exposure to the superheated steam and heat source for a period of time not only browns such a thin product, but can fully cook it.

[0076] By using different browning 14 and cooking chambers 44, the temperatures of each and\or the heating sources therefore, can be different, if desired. For example, the browning employing superheated steam might occur in the chamber 14 at a lower temperature than in the cooking chamber 44. Also, the separate cooking source could be a microwave oven, a hot air impingement oven, an infrared oven, etc. Similarly, if external heat is added in the browning chamber 14, it can be from hot air, infrared, etc. Further, by using separate browning and cooking chambers, there is better control over product throughput, yield and color consistency. Thus, the separate cooking chamber adds flexibility and control. As the browning phase creates a relatively harsh environment for full cooking, a separate cooking phase can be accomplished with a lower temperature and more wet steam.

[0077] An important feature of this embodiment is that it has essentially two stages of cooking while still being a continuous process, fed by the conveyor. Browning is accomplished in a first chamber 14, then full cooking occurs in the adjacent chamber 44. Of course the direction of the

conveyor could be reversed to cook the product before the high temperature browning. However, it is normally advantageous with most commercial cooking, wherein the product is frozen or cold before entering the oven, to first brown the food product. This effectively browns the surface without breaking down internal fats, oils and moisture. Then slower, lower temperature full cooking would take place, and the overall loss of these fats, oils and moisture is far less than if the product were first heated to, say, 120° F. internally in a cooking oven 44 and then subjected to the very high temperature radiant walls in the chamber 14 for the browning characteristics.

[0078] In the case of a microwave oven, a conventional metal conveyor belt 18 cannot be used. The conveyor is typically of plastic materials, as is known in the commercial microwave industry. In the usual case wherein browning is accomplished first, a metal conveyor from the processor 10 passes adjacent to a plastic conveyor destined for the microwave for cooking. Food products 16 are transferred between the metal and plastic conveyors via known rollers.

[0079] Other types of heat sources that are applicable to the present invention include convection, smoke house, hot air impingement, other types of infrared, such as electrical resistance instead of liquid or gas fueled, or any other type of oven that provides a heat source.

[0080] Instead of separate browning and cooking chambers, the processor 10 can include a single chamber for both browning and cooking, so that the food product can be browned and cooked at the same time. See, e.g., Fig. 3. The superheated steam 20 and the heat for the cooking would exit into the same chamber, and the food products would be moved through this single chamber to be simultaneously browned and cooked. Again, either the cooking could occur first, or the browning, as desired.

[0081] Thus, in any of the embodiments above, wherein a cooking unit is employed either integrally or separately, the present invention also has the advantages of being able to brown and cook a food product in a single cycle, on a single conveyor path.

[0082] The invention also includes the use of superheated steam to cook the food product. That is, the processing time required to fully cook the food product to a desired internal temperature can also be decreased when the product is placed in a superheated steam environment. As shown in Fig. 6, the superheated steam for cooking could be introduced into the cooking chamber 44 via inlet 58.

[0083] This processing time for cooking can be further decreased when the food product 16 is placed in a superheated steam environment in combination with lower temperature, i.e.,

conventional steam (160°F to 212°F). Again, inlet 58 can be used for introduction of the conventional steam. Alternatively, separate inlets can be used for the superheated steam and conventional steam, respectively.

[0084] The conventional steam serves the purposes, when mixed with the superheated steam, of reducing the temperature of the superheated steam that gets to the surface of the food product, and to increase the humidity of the oven chamber 44, where desired. Even with the addition of conventional saturated steam to the superheated steam, the overall mixture in the chamber 44 is still relatively dry.

[0085] This mixing of superheated and non-superheated steam can be utilized to create the desired atmosphere in the processing equipment to maximize product yield, and maintain proper desired browning characteristics of the product, while decreasing time for thermal processing to a desired internal product temperature.

[0086] It is also possible to introduce conventional steam anywhere along the conveyor path, and only periodically introduce superheated steam into the chamber, thereby effecting a mix of conventional and superheated steam.

[0087] Without further elaboration, it is believed that one skilled in the art, using the preceding description, can utilize the present invention to its fullest extent. The following examples, therefore are to be construed as merely illustrative, and not limitative in any way whatsoever, of the remainder of the disclosure.

EXAMPLES

[0088] A series of food products 16 was introduced into a steam cabinet 10 via the conveyer 18 under one of the following conditions: (a) with the addition of superheated steam; and (b) without the addition of superheated steam. The steam cabinet temperature and belt speed remained constant.

[0089] Photographs of each product were taken to show the relative browning of the food products in the superheated steam environment.

Example 1

[0090] Boneless, skinless chicken breast was purchased at a supermarket. The product was not processed in any manner prior to the following browning process according to the present invention. The food product was placed in the steam cabinet and superheated steam was applied. The product was removed after browning occurred. The temperature of superheated

steam entering the steam cabinet was 372°F. The temperature of the processing environment in the steam cabinet was 266°F. The dwell time of the product in the steam cabinet was 82 seconds. The food product exhibited a light brown color with even browning. See Fig. 7.

Example 2

[0091] Breakfast sausage links were purchased at a supermarket, and were not processed in any manner prior to the browning process described below. The product was placed in the steam cabinet and superheated steam was applied. The superheated steam delivery was positioned directly above the sausage links (less than 8" from the top of the product). The product was removed after browning occurred. The temperature of the superheated steam entering the steam cabinet was 412°F. The temperature of the processing environment in the steam cabinet was 300°F. The dwell time of the product in the steam cabinet was 90 seconds. The product exhibited a dark brown color with even browning. See Fig. 8.

Example 3

[0092] A sample of the sausage product, as discussed in relation to the Example 2 above, was browned with superheated steam, according to the present invention, and fully cooked with non-superheated (conventional) steam.

Example 4

[0093] A sample of the sausage product, as discussed in relation to Example 2 above, was browned with superheated steam, and fully cooked with superheated steam, both according to the present invention.

Example 5

[0094] The same sausage product, as discussed in relation to Example 2 above, was browned with superheated steam, fully cooked with a combination of superheated steam and non-superheated steam, both according to the present invention.

[0095] The data in Table 2 below explains the test parameters of Examples 3-5 listed above. The table illustrates that the sausage food products that were tested according to the present invention's use of superheated steam, which exhibited significantly increased browning, did not result in significant shrinkage.

TABLE 2

Ex.	Raw Wt. (g)	Super-heated Steam Temp.	Steam Cab. Temp	Browning Dwell Time	Browned Product Temp.	Browned Product Wt. (g)	Superheated Steam Temp. (Cook Process)	Steam Cabinet Temp.	Cook Product Temp.	Cook Dwell Time.	Cooked Product Temp.	Cooked Product Wt. (g)	Finished Yield
3	470g	412°F	300°F	90 Sec.	106°F	435g	Not Used	203°F	191°F	174 Sec.	165°F	425g	90.43%
4	475g	414°F	301°F	90 Sec.	108°F	440g	411°F	Not Used	299°F	132 sec.	166°F	420g	88.98%
5	470g	411°F	300°F	90 Sec.	108°F	435g	411°F	205°F	265°F	150 sec.	166°F	430g	91.49%

[0096] In the above Examples 1-5, a steam cabinet was used as part of the processor 10. In the following examples. Superheated steam was generated and introduced into the processor 10 (including a radiant wall oven) throughout the length of the effective infrared zone of the radiant wall oven chamber.

Example 6

[0097] Boneless thin sliced pork chops were purchased at a supermarket. See Fig. 9A. The product was not processed in any manner from the time it was removed from the package until the time it was introduced into the radiant wall oven.

[0098] Samples of the product were placed in the radiant wall oven without the addition of superheated steam. The operating temperature of the radiant wall oven was 1100°F. Product dwell time in the oven was 64 seconds. The product exhibited a light brown color with more intense browning noted towards the edges of the product. See Fig. 9B.

[0099] Samples of the product were placed in the radiant wall oven with the addition of superheated steam according to the present invention. The operating temperature of the radiant wall oven was 1100°F. Product dwell time in the radiant wall oven was 64 seconds. Delivery temperature of the superheated steam was 412°F. The product exhibited a much more golden brown color with more even color distribution. See Fig. 9C.

Example 7

[00100] Hot peppers were purchased at a supermarket. See Fig. 10A. The product was not processed in any manner from the time it was removed from the package until the time it was introduced into the radiant wall oven.

[00101] Samples of the product were placed in the radiant wall oven without the addition of superheated steam. The operating temperature of the radiant wall oven was 1100°F. Product

dwell time in the radiant wall oven was 64 seconds. The product exhibited slight browning with uneven color distribution. See Fig. 10B.

[00102] Samples of the product were placed in the radiant wall oven with addition of superheated steam. The operating temperature of the radiant wall oven was 1100°F. Product dwell time in the radiant wall oven was 64 seconds. Delivery temperature of the superheated steam was 416°F. The product exhibited a very dark brown to almost black color throughout. See Fig. 10C.

Example 8

[00103] Farm raised salmon filets were purchased at a supermarket. See Fig. 11A. The product was not processed in any manner from the time it was removed from the package until the time it was introduced into the radiant wall oven.

[00104] Samples of the salmon product were placed in the radiant wall oven without the addition of superheated steam. The operating temperature of the radiant wall oven was 1130°F. Product dwell time in the radiant wall oven was 90 seconds. The product exhibited slight browning towards the edges of the product . See Fig. 11B.

[00105] Samples of the salmon product were placed in the radiant wall oven with the addition of superheated steam. The operating temperature of the radiant wall oven was 1130°F. The product dwell time in the radiant wall oven was 90 seconds. The delivery temperature of the superheated steam was 393°F. The product exhibited a rich brown appearance with blackened notes traditionally accepted for this type of product. The color distribution was greater than the salmon sample discussed immediately above where no superheated steam was used. Compare Fig. 11C with Fig. 11B, respectively.

Example 9

[00106] Bone in turkey breasts were purchased at a supermarket. See Fig. 12A. The product was not processed in any manner from the time it was removed from the package until the time it was introduced into the radiant wall oven.

[00107] A sample of the turkey product was placed in the radiant wall oven without the addition of superheated steam. The operating temperature of the radiant wall oven was 1130°F. Product dwell time in the radiant wall oven was 74 seconds. The product exhibited slight browning towards the edges and wing tips of the product. See Fig. 12B.

[00108] A sample of the product was placed in the radiant wall oven with the addition of superheated steam. The operating temperature of the radiant wall oven was 1130°F. Product dwell time in the radiant wall oven was 74 seconds. The delivery temperature of the superheated steam was 396°F. The product exhibited an even browned appearance with some burning of the skin on the top of the product, which was close to the superheated steam delivery. The color distribution was greater than the turkey sample immediately discussed above. Compare Fig. 12C with Fig. 12B, respectively.

[00109] The following additional tests shown in Table 3 below were performed using a processor 10 incorporating a radiant wall oven, wherein the superheated steam is generated by the coil 64 placed in the plenum 46 of the oven, between walls 42 and 12. The controller 32 measured the temperature of the superheated steam, the oven atmosphere in the chamber 44, and the oven wall 42 temperature.

TABLE 3

Product	Raw Wt.	Oven Wall Oven Temp./Dwell	Superheated Steam Temp.	Oven Atmosphere Temp.	Browned/ Cooked Wt.	Browned/ Cooked Yield	Comments
Chicken Breast 3"	195g	1075°F @ 70 Sec.	790°F	850°F	180g	92.31%	Light in Color
Chicken Breast 2.5"	160g	1075°F @ 80 sec.	785°F	816°F	145g	90.62%	Same as Above
Chicken Breast 2.25"	225g	1100°F @ 80 sec.	782°F	845°F	210	93.33%	Much Darker

[00110] In the following tests, shown in Table 4, superheated steam was introduced into a steam cabinet. A radiant wall oven was only used for the purpose of generating the superheated steam.

TABLE 4

Product	Raw Wt.	Radiant Wall Oven Temp./Dwell	Superheated Steam Temp.	Oven Atmos. Temp.	Steam Dwell	Cooked Wt.	Final Yield
Bacon	210g (10 Strips)	1100°F	524°F to 593°F	326°F to 388°F	7 Min.	65g	31.43%
Bacon	105g (6 Strips)	1100°F	620°F	468°F	3 min. 17 sec.	45g	42.86%

[00111] In these bacon examples, the bacon exhibited better color and texture than conventional precooked bacon, which relies upon a microwave cooking process. The process could also be reduced, to about 3 minutes, when the superheated steam was introduced from both above and below the food products.

[00112] In the following test, shown in Table 5, a radiant wall oven was used to brown, and a steam cabinet was used to cook, the chicken breasts. The steam cabinet used a mixture of superheated steam and conventional (wet) steam at an average combined temperature of 300°F.

TABLE 5

Product	Raw Wt.	Radiant Wall Oven Temp./Dwell	Superheated Steam	Radiant Wall Oven Atmos.	Browned Wt.	Browned Yield	Steam/ Cabinet Temp.	Steam Dwell	Wt./Yield/Prod. Internal Temp	Comments
Chicken Breast *(unmarinated)*	1150g	1080@76 sec. (1.4)	888°F	888°F	1040g	90.43%	300/300	11 min.	855g/74.38% 166°F	Golden Brown in Color

[00113] In the following tests, shown in Table 6, when a radiant wall oven with superheated steam was used for browning, and a steam cabinet with superheated steam was used for cooking, yield was maintained at shorter dwell times than conventional.

TABLE 6

Product	Raw Wt.	Radiant Wall Oven Temp./Dwell	Superheated Steam Temp.	Radiant Wall Oven Atmosphere Temp.	Distance of Product from Belt	Browned Wt.	Browned Yield	Steam Temp/Cabinet Atmos. Temp.	Steam Dwell	Wt./Yield
Bone in Chicken Breast	655g	1150 @ 1 min.45 sec. (1.1)	530°F	722°F	4"	635g	94.95%	360°F/351°F	23 min.	515g/78.62%
Bone in Chicken Breast	675g	1150@1 min.45 sec. (1.1)	534°F	730°F	4"	655g	97.04%	360°F/351°F	23 min.	540g/80.00%
Bone in Chicken Breast	695g	1150@1 min.45 sec. (1.1)	737°F	830°F	4"	660g	94.96%	360°F /351°F	23 min.	545g/78.42%
Bone in Chicken Breast	695g	1150@1 min.45 sec. (1,1)	740°F	829°F	4"	655g	94.24%	360°F /351°F	23 min.	2155g/79.23%
Chicken Wings	1400g (33 sections)	1150 @ 1min. 56 sec. (1.)	760°F	769°F	3"	1125g	80.36%	365°F /340°F	4 min. 35 sec.	1030/73.57%
Bacon	215g	Steamer Only	Steamer Only	Steamer Only	Steam er Only	Steamer Only	Steamer Only	504°F /463°F	3 min. 18 sec.	80g/37.21%
Bacon	170g (8 slices trimmed)	Steamer Only	Steamer Only	Steamer Only	Steam er Only	Steamer Only	Steamer Only	460°F /490°F	2 min. 16 sec.	65g/38.24%
Bacon	270g (12 Slices Trimmed)	Steamer Only	Steamer Only	Steamer Only	Steam er Only	Steamer Only	Steamer Only	480°F /514°F	5 min. 40sc.	105g/38.88%

[00114] In the following tests, shown in Table 7 in each box steamer only hamburger patties (85% lean) were browned in a radiant wall oven processor 10, wherein a coil 64 is used to generate the superheated steam. This test was performed to estimate a preferred distance between the food product and the superheated steam outlet, both above and below. In each instance, the product was raised or "lifted" up from the conveyor belt towards the superheated steam slots 29, which were immovably mounted, in this case, 6" above the belt. Thus, if the product is raised or lifted 4" above the belt, it is actually 2" from the superheated steam slots.

TABLE 7

# of Patties/inches of lift	Raw Wt.	Radiant Wall Oven Temp	Superheated Steam Temp.	Atmos.	RWO Wt./Product Internal Temperature	Comments
1 patty – 4" Lift	120g	1.8=68 sec @ 1000°F	729°F	820°F	110g at 108°F	More browning on top – need lower lift and top – bottom steam adjust
1 patty – 3" Lift	115g	1.2=92 sec @ 1050°F	752°F	799°F	105g at 109°F	More browning on bottom
1 patty – No. Lift No Steam	115g	1.2=92 sec @ 1100°F	775°F	803°F	105g at 108°F	Very light-almost no browning
1 Patty-2" Lift	120g	1.2=92 sec @ 1100°F	802°F	820°F	95g at 117 °F	Excellent browning on both sides

[00115] It was found that a 2" lift off the belt was preferred.

[00116] In the following test, shown in Table 8, superheated steam was introduced into a small steam cabinet from a coil 64 inside the radiant wall oven firebox. A bacon belly was cut into 4 sections to fit the cabinet. The belly was drenched in a 20% solution of Zesty$_{TM}$ super smoke 100 poly liquid smoke. The following table represents the cook/brown process for the belly sections.

TABLE 8

Process Notes	Steam Temp.	Steam Dwell	Cooked Wt./Internal Temp.	Yield	Comments
Belly section drenched in SS-100P at 20% - cooked skin side up - steamer started cold @ 212°F and gradually warmed up to 344°	212°F to 344°F	38 min	1220g@127°F	88.0%	Acceptable color and texture
Belly section drenched in SS-100P at 20% - cooked skin side down - steamer started hot @ 330°F and gradually warmed up to 476°F after 16 min. (Internal temperature was 104°F), switched - over to wet steam, and turned oven off - Steam temp. dropped to 337°F when product was finished, cooking - cooked start wt. was 1510g	330°F to 476°F to 337°F	27 min	1335g @ 137°F	88.9%	Acceptable color and texture with shorter cook time due to higher starting temperature, Note: Yield would be higher if temp. was lower (127°F).

[00117] The following describes additional tests performed regarding the use of superheated steam cooking, superheated steam/conventional steam cooking, regardless of whether the food product is browned prior to cooking or by whatever process it is browned, according to conventional processes or the superheated steam process of the present invention described above.

[00118] A radiant wall oven was used to generate superheated steam, as described above. That is, a 2' coil was placed in the fire box of the radiant wall oven to elevate the temperature of the steam in the coil for delivery to an abbreviated test steam cooking cabinet 80 shown in Figs. 13 and 14.

[00119] Superheated steam control was effected by a Spirax Sarco steam mixer, modulating valves, thermocouples, and flow meter to control and measure the temperature and flow of the superheated steam to the cooking cabinet 80. Conventional steam control was effected by a

Spirax Sarco flow meter, modulating valve, and thermocouple to control and monitor the temperature and flow of the conventional steam to the cooking cabinet 80.

[00120] The cabinet 80 included an insulated stainless steel housing with an effecting cooking zone defined by a 3' length receiving a 24" wide continuous belt 84. The belt was driven by a variable speed drive. Due to the relatively short length of the effective cooking zone (i.e., 3') of this test device, the belt 84 was stopped during the cooking process to simulate a continuous process (an actual device might be 40' long). That is, the conveyor was stopped to allow the product to experience the full superheated/conventional steam dwell times noted below, with the superheated steam being used first, followed by the saturated steam application.

[00121] The steam delivery for the superheated steam in this example consisted of eleven (11) ¾" OD stainless steel tubes (5 tubes 86a above the product and 6 tubes 86b below the product) running the length of the cabinet 80. Each tube 86 in this example contained thirteen (13) .035" X .785" evenly-spaced slots 88 for superheated steam delivery. The distance from the delivery point of each tube 86 was about 4" below the belt and about 9" above the belt upon which the product to be cooked is placed. The spacing between the upper tubes 86a and the belt 84 allowed about 5" in which to accommodate the food product 90, with the upper and lower tubes 86a and 86b being placed approximately equal distances from the top and bottom of the food product 90, respectively.

[00122] The conventional, i.e., saturated, steam was delivered in this example by four (4) ¾" OD stainless steel tubes 92. Two tubes 92 are located on each side of the cabinet. Each tube 92 again runs the length of the cabinet. Relatively lower tubes 92b are placed approximately 4" above the belt 84, whereas upper tubes 92a are placed approximately 9" above the belt 84. Each tube 92 again contains, in this example, thirteen (13) .035" X .785" evenly-spaced slots 94 for conventional steam delivery.

[00123] This embodiment creates an increased humidity environment in the product zone simulating a conventional steam cooking environment. The ability to add superheated steam to conventional steam greatly reduces dwell time while maintaining yield.

[00124] Test results are shown below. In analyzing the results, it is important to note that in any food processing, dwell time is a significant consideration in obtaining efficiencies. However, yield is also important, as it is preferred to maintain as much of the original product weight as possible.

TABLE 9

Test #	Product	Initial Prod Temp.	Initial Prod. Wt.	SHS Temp	SHS Flow	SHS Dwell	Saturated Temp	Saturated Flow	Saturated Dwell	Cooked Wt.	Final Prod. Temp.	Prod. Yield
1	Boneless Chicken Brest	42°F	1220g 7 pcs.	None	None	None	201 to 207°F	235 to 240kg/hr	17min. 40sec.	1035g	164 to 172° F	84.8%
2	Boneless Chicken Brest	42°F	1160g 7 pcs.	625 to 630°F	315 to 320 kg/hr	6 min 15 sec	None	None	None	845g	166 to 170° F	72.8%
3	Boneless Chicken Brest	42°F	1205g 7 pcs.	625 to 630°F	315 to 320 kg/hr	2min 35sec.	202 to 208°F	235 to 240kg/hr	9min. 20 sec.	1020g	165 to 171° F	84.6%
4	Boneless Pork Chops	45°F	1450g 10 Chops	None	None	None	204 to 210°F	235 to 240kg/hr	8min. 40sec.	1260g	161 to 164° F	86.9%
5	Loin Back Pork Ribs	45°F	1430 10 Chops	625 to 630°F	315 to 320 kg/hr.	4 min 35 sec	None	None	None	1065g	160 to 164° F	74.5%
6	Loin Back Pork Ribs	45°F	1475 10 Chops	625 to 630°F	315 to 320 kg/hr.	2min 20sec.	205 to 209°F	235 to 240kg/hr	4 min. 20 sec.	1280g	161 to 163° F	86.8%

SHS - Superheated Steam

Saturated - Conventional Steam

Tests 1&4 – Conventional Steam Only

Tests 2&5 – Superheated Steam Only

Tests 3&6 – Combination Cooking Using SHS and Saturated

[00125] As can be seen from the above, the use of SHS alone shortened dwell times but did not maintain yield.

[00126] The combination of SHS and saturated steam greatly reduced dwell time while maintaining the yield. The combination adds high heat transfer at the start of the process. The use of SHS at the start of the process can also aid in browning or searing of the surface to help maintain moisture throughout the cooking process.

[00127] The number and placement of the tubes 86, 88 and 92 can vary. That is, the steams can be introduced from anywhere around the foot product. It is believed, however, that the

superheated steam would be more effective if introduced from above and below, since heat transfer would be better from these sites.

[00128] Also, the superheated steam can be introduced to the food product first to expose the product to high BTU's, but then decreased or terminated, and the saturated steam is then introduced to increase humidity and minimize shrinkage. In other applications, the superheated and saturated steam applications can overlap along the conveyor, as needed. For example, where it is desired to increase BTU's getting to the food product, the SHS application would be longer than the example shown in TABLE 9.

[00129] The preceding examples can be repeated with similar success by substituting other products for those described above.

[00130] While the use of artificial browning agents is no longer necessary with the present invention, there may be specific instances where the use of such conventional agents may be desirable. For example, with whole chickens or turkeys, using a browning agent will help avoid areas such as under the wing which might appear whitish since the superheated steam may not be able to impinge upon and fully brown such areas.

[00131] Also, it is known in the art to apply branding stripes to some food products to impart an appearance of grilling. See, e.g., U.S. Patent No. 4,297,942, issued to Caridis et al. Again, if desired, this conventional striping can be used with the present invention.

[00132] The foregoing is considered illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described. Accordingly, all suitable modifications and equivalents may be resorted to that fall within the scope of the invention and the appended claims.